of Cuba than from South America by way of the Lesser Antilles; certainly not from North America. But it seems doubtful whether any former continental connection is indicated, the mammalian fauna, like that of Cuba, etc., being limited to a few groups which can be accounted for in other ways.

Mr. E. L. Troxell[21] describes the skeleton of a Pliocene horse which is in many respects intermediate between the three-toed horses of the Miocene and the true *Equus* of the Pleistocene. It is referred to the genus *Pliohippus,* but is much more complete and more truly intermediate in character than the type species described many years ago by Marsh. A second and more complete skeleton has recently been discovered in western Nebraska; both are in the American Museum in New York. [W. D. M.]

C. R. EASTMAN,
W. K. GREGORY,
W. D. MATTHEW

SPECIAL ARTICLES

THE REFLECTION OF γ-RAYS BY CRYSTALS[1]

RUTHERFORD and Andrade[2] have shown that when γ-rays fall on the faces of crystals at certain angles regular reflection takes place as in the experiments of Bragg[3] with X-rays. This should show itself by an increase of absorption of the γ-rays, and in the experiments to be described evidence has been obtained of this character.

A fine pencil of γ-rays passed through a vessel containing a crystalline substance into an ionization chamber where the ionization was measured. The crystalline structure of the absorber was then destroyed either by powdering, melting or by dissolving in water, and any change in the ionization current was measured by a balance method. The change in the ionization gives a measure of the radiation which is reflected from the crystals at such an angle with the direction of the beam as not to enter the ionization chamber. The experimental arrangement is shown in Fig. 1.

The small thin glass crystallizing dish *D,* containing the crystals under investigation was placed over a hole in the lead block *L* so as to rest either directly on the lead block or on an adjustable iron-gauze shelf above it. The γ-rays from the source *S* passed through the crystals and hole, which was 1.2 cm. in diameter, and through a very thin sheet of aluminum foil into the ionization chamber *A*. The balance chamber *B* also received γ-rays from the source through a thick adjustable lead slit *R*. Electrodes passing into *A* and *B* through earthed guard rings were connected to a Wilson-Kaye electroscope *E*. The chambers *A* and *B* were hollow brass cylinders 15 cm. long and 8 cm. in diameter. They were insulated and connected to —200 volts and +200 volts, respectively. By means of the key *K* the gold leaf could be earthed or joined to a divided megohm in series with a storage battery for the purpose of measuring the sensibility of the leaf. The leads to the electroscope from the chambers *A* and *B* were completely shielded by brass tubing and lead foil earth connected, so that electrostatic effects were eliminated. The balance chamber *B* was surrounded by a lead sheet 3 mm. thick to prevent any soft scattered radiation from entering it, and all connections to the electroscope were shielded as much as possible from direct radiation by thick blocks of lead. The lead block *L* was 7.5 cm. thick, and for the position of the source used in most of the experiments about twenty-five times as much ionization was produced by the rays passing through the hole as through the rest of the block.

Owing to their short wave-lengths the angles of reflection for γ-rays are probably small. It is, therefore, necessary to use a small cone of

[21] *Amer. Jour. Sci.,* Vol. 42, pp. 335–348, 7 text figs.

[1] This article was written in April, 1914, and describes some experiments performed in Professor Sir Ernest Rutherford's laboratory at the University of Manchester. At that time Rutherford and Andrade were working on the same problem by the more direct method. While the results recorded in this paper have apparently little quantitative value, the general method of attack may be of sufficient interest to justify their publication.

[2] Rutherford and Andrade, *Phil. Mag.,* May, 1914, p. 854.

[3] Bragg, *Phil. Mag.,* May, 1914, p. 881.

rays from a strong source and to work at high sensibility. The sensibility used in the different experiments was varied between 125 and 50 divisions per volt and was measured after each reading of the electroscope.

With the crystals in position a balance was obtained between the two ionization currents in the two chambers. Any change in absorption would then be shown by a corresponding motion of the leaf of the electroscope. In practise it was found unwise to attempt to adjust the balance very accurately when using strong γ-ray sources, since small fluctuations appeared in the movement of the leaf, possibly due to the Schweidler effect.

EXPERIMENTS WITH POWDERED CRYSTALS

The crystallizing dish was filled with the crystals of a given material and placed as shown in Fig. 1. The lead slit was then adjusted until a small leak was observed in the electroscope and the average of a number of readings taken. The crystals were then reduced to a fine powder in a mortar and this powder pressed down in the dish to produce the same thickness of layer as in crystal form. The leak was then read as before.

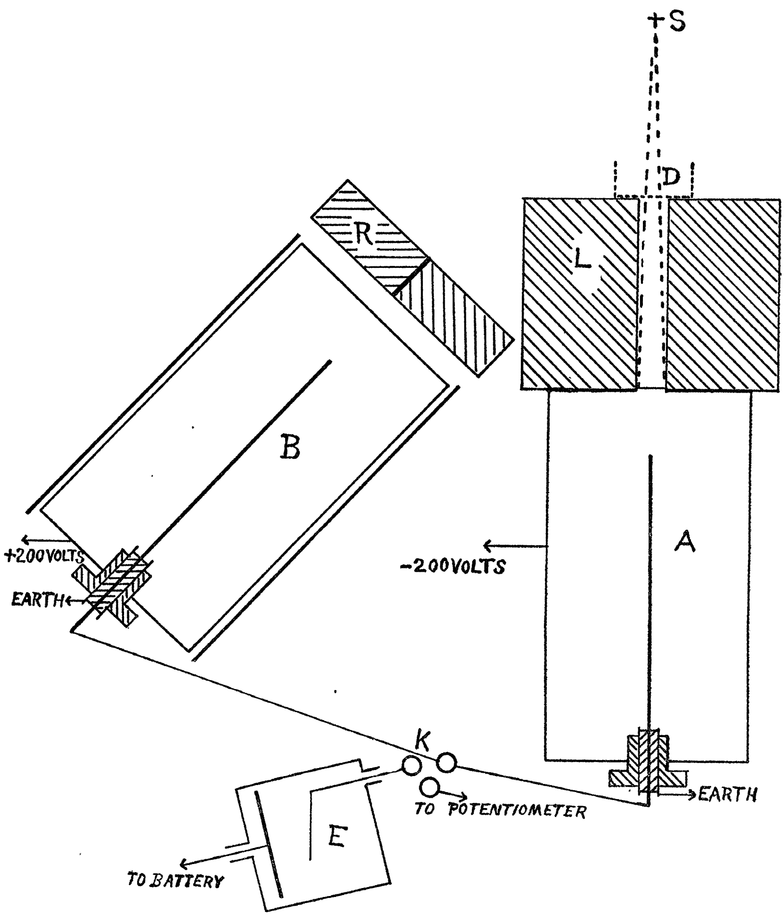

Fig. 1

A decrease in absorption corresponding to a diminution in reflection in general took place. In most of the experiments a 14 mg. radium standard was used as source of γ-rays. A

TABLE I

Position of Crystals	Leak in Div. per Min. Max. Size 1.5 × .5 Cm.	Leak in Div. per Min. Max. Size .5 × .5 Cm.	Leak in Div. per Min. Powdered	Max. Change Due to Absorption	Percentage of Cone Absorbed
On lead block	27.5, 30.4, 31.8, 29.8 mean 29.9	25.6, 25.5, 25.7 mean 25.6	20.4, 21.7 mean 21.1	8.8	2.3
5 cm. above lead block	14.5, 13.5, 13.6 mean 13.9	12.8, 13.0 mean 12.9	7.9, 7.7, 7.9 mean 7.9	6.0	1.5

large number of tests were made using lead nitrate crystals with γ-ray sources varying from 200 to 14 millicuries of radium emanation, the source and crystals being placed at different distances from the chamber *A*. The sensibility of the electroscope was also varied over a wide range.

Table I. gives a summary of the results obtained for six separate experiments with lead nitrate.

The percentage of total beam absorbed was obtained by dividing the total change in absorption from crystalline to non-crystalline state by the leak due to the entire cone of rays measured by connecting chamber *B* alone to the electroscope. For the above experiments in which a layer of lead nitrate crystals 3.4 cm. thick was used, with the 14 mg. standard as source of rays, this reading was 415 divisions per min.

TABLE II

Material	Number of Experiments	Weight in Grams.	Thickness of Layer in Cm.	Percentage of Total Beam Absorbed
Lead nitrate	17	250–70.5	3.4–1.2	2.3– .4
Lead acetate	8	196–29.2	3.5– .6	4.8–1.0
Potassium sulphate	4	106	2.5	1.6–1.0
Hydrogen potassium sulphate	2	89	2.5	.6– .4
Potass. dichromate	2	106	2.5	.34–.26
Mercuric bromide	1	124	2.5	1.0
Mercury nitrate	1	163	2.5	1.3

A detailed study of the effect was made using γ-ray sources varying from 200 to 14 millicuries of radium emanation, the source and crystals being placed at different distances from the chamber *A*. The sensibility of the electroscope was also varied over a wide range. Table II. gives a summary of results obtained for a number of crystalline materials.

Since the size of the crystals differed greatly and other conditions of experiment were not the same in all cases, it is not possible to attempt any quantitative comparison of these results. They are inserted as an indication of the order of the effects observed.

EXPERIMENTS WITH CRYSTALLINE MERCURY

A more direct method would be to note the relative γ-ray absorption for some substance which could easily be obtained in crystalline and non-crystalline states. Water and mercury satisfy these conditions. Owing to the large density of the latter, it should produce a good deal of γ-ray scattering, and since it melts rapidly the sensibility of the electroscope would not alter appreciably during an experiment. The radiation entering the balance chamber was adjusted so as to give a very slow rate of leak of the electroscope for a given weight of mercury. The mercury was then removed and solidified in a Dewar vessel by the use of carbon-dioxide snow. The rates of leak with the solid mercury were then measured and observations taken as melting proceeded. More than 40 separate tests were made under widely varying experimental conditions, but while the data in general showed a small decrease in absorption for the fluid state, it was in most cases little more than the experimental error. The crystals obtained in every case were very minute.

SOLUTION EXPERIMENTS

A number of attempts were made to note a change in absorption for lead nitrate entering into solution. Other soluble crystalline substances were also tried including salt, sugar, etc. A large crystallizing dish containing 600

c.c. was used nearly filled with water and a uniform layer of medium-sized crystals placed on an iron gauze shelf midway between the bottom and the surface of the water. Any change of absorption was noted as the crystals went into solution. Slight changes took place as the material dissolved and went to the bottom, yet after a thorough stirring when solution was complete the readings of the electroscope returned to almost the initial value. A small decrease in absorption was noted, however, in the majority of the experiments.

It is hoped to repeat these experiments for mercury and solutions, using more refined apparatus and methods, and to study the effect of crystalline structure on reflection by an examination of changes in absorption for substances of high molecular weight which crystallize in two forms such as lead nitrate, mercury perchloride and mercury iodide.

In conclusion I wish to express my indebtedness to Professor Sir Ernest Rutherford for suggesting this general field of research; also to Dr. Ernest Marsden for many helpful ideas.

P. B. Perkins

Brown University

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 561st meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, December 2, 1916, called to order by President Hay at 8 p.m., with 50 persons in attendance.

The following program was rendered:

The Discovery of an Interesting New Tardigrade: W. P. Hay.

Professor Hay gave a brief description of a tardigrade belonging to the genus *Batillipes* discovered by him some years ago at Beaufort, N. C. It is closely related to *B. mirus* Richters but differs from that species in a number of important characters.

The structure and relationship of the tardigrades was discussed and the conclusion was reached that *Batillipes*, in spite of its evident specialization along certain lines, is probably the most primitive genus of the group.

From *Batillipes* through *Halechiniscus* to *Oreella* and *Echiniscus* was suggested as one line of development, while from *Echiniscoides* through *Milnesium* to *Macrobiotus* and *Diphascon* appears to be another. The genus *Tetrakentron* with its single species *T. synaptæ* shows a high degree of specialization due to parasitism and *Microlyda* is probably the larval form of *Halechiniscus.*

Attention was called to the habitat of the bear animalcules belonging to these genera. Five of them, *Batillipes, Halechiniscus, Microlyda, Tetrakentron* and *Echiniscoides* are marine. *Echiniscus* and *Oreella* are strictly terrestrial. *Macrobiotus* is mostly terrestrial or lacustrine but is represented in salt water by at least two species. *Diphascon* is terrestrial and lacustrine.

The fact that the majority of the genera are marine and that this list includes all the more primitive genera points strongly to a marine origin for the group. It also supports the idea advanced by Professor Richters in 1909 that the tardigrades are probably most closely related to the chætopod worms and should be removed from the class Arachnida in, or near, which the group is usually placed in our zoological text-books.

Professor Hay's communication was illustrated by charts and diagrams.

Exhibition of Venezuelan Plants and Fruits: J. N. Rose.

Dr. Rose had on exhibition a large table full of fruits, fruit products and various articles made of parts of Venezuelan plants. He explained their usage and described the plants from which they were obtained. The specimens were obtained for the most part in the vicinity of La Guaira and Caracas. Dr. Rose's communication was discussed by Messrs. H. Pittier, M. W. Lyon, Jr., and others.

Poisonous Snakes: M. W. Lyon, Jr.

Dr. Lyon gave an account of the various specific substances that have been found in snake venoms, and outlined their modes of action on the various tissues of bitten animals. He spoke of the various antiserums that have been prepared against these venoms, and their therapeutic uses. He also called attention to the non-specific treatment of snake-bites in the light of modern statistics and experiments. He then gave a brief outline of the classification of venomous snakes, their geographic distribution, of the development and structure of the poison gland and fang. His communication was illustrated by lantern slide views of skulls, glands and fangs of poisonous snakes, of types of poisonous snakes and of some of the histological changes caused by snake venom. This communication was discussed by Messrs. A. A. Doolittle, H. Pittier, H. M. Smith, H. E. Ames and T. E. Wilcox.

M. W. Lyon, Jr.,
Recording Secretary